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Red Lionfish

A "Super-Invader" for Supper?

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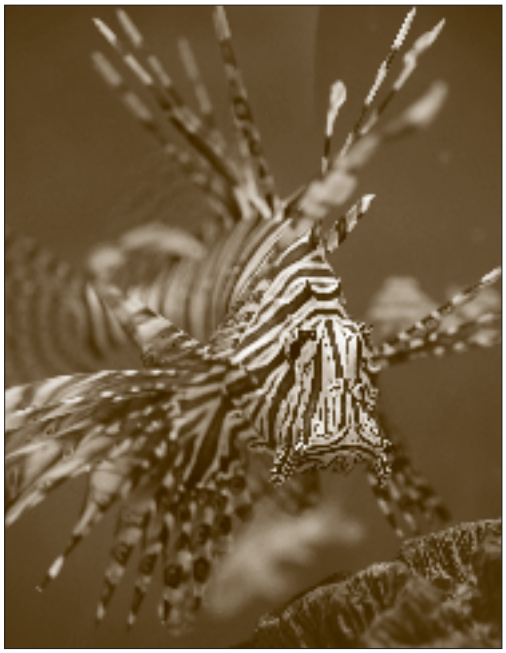

ON THE COVER:

Although the red lionfish is a beautiful creature, it's the most invasive reef fish in the world.

PHOTO/GRACE BEAHM

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PROLIFIC INTERLOPER. *Red lionfish populations have become hugely abundant in biologically rich marine environments of the western Atlantic and Caribbean.*
GRAPHIC/DAWN WITHERINGTON/LOXAHATCHEE RIVER DISTRICT

Red Lionfish

A "Super-Invader" for Supper?

by John H. Tibbetts

Is your grouper local? Top lowcountry chefs wish they could say yes every time. They'd like to serve grouper that's right off the dock. But the most sought-after reef fish often aren't available from local waters. So chefs tend to acquire week-old grouper from the Gulf of Mexico or serve fresh but less-known substitutes such as triggerfish or tilefish.

From the mid-1970s to the early 1990s, overfishing decimated commercially valuable snapper-grouper stocks from eastern Florida to the Carolinas. In turn, fishery managers have crafted increasingly tough restrictions in an effort to restore those stocks to health.

Yet some fisheries haven't bounced back. Why?

Could it have something to do with the stunningly successful invasion by the red lionfish, *Pterois volitans*?

The red lionfish, a native of the Indo-Pacific region, has become an abundant top-level predator in the western Atlantic and the Caribbean. On many reefs, lionfish outnumber snappers, groupers, and other native predators.

A gorgeous and graceful swimmer, the lionfish is a modest-size animal, averaging only about a foot in length. But it's a "super-invasive" species, a perfect storm churning through biologically rich marine habitats across thousands of miles.

"By far, the lionfish is the most invasive and aggressive reef fish on the planet," says James A. Morris, an ecologist with the National Oceanic and Atmospheric Administration (NOAA) National Center for Coastal Fisheries and Habitat Research laboratory in Beaufort, North Carolina.

It swallows crustaceans, juvenile predators, and small adult herbivores such as damselfish and parrotfish, consuming food that otherwise would be available for mature groupers and snappers.

In the Caribbean where coral reefs are critical to fishing and tourism economies, the lionfish is feared as one of the most devastating invasive species

This map indicates sites where red lionfish populations have been reported since the 1990s. North of Cape Hatteras, however, red lionfish do not survive cold winters and die before spawning.
MAP/U.S. GEOLOGICAL SURVEY, REEF ENVIRONMENTAL EDUCATION FOUNDATION, AND NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

over the past century—in a special class of notoriety with Asian carp, kudzu, and the zebra mussel.

Yet the lionfish receives little public attention in South Carolina where it inhabits ledges and rocky bottoms offshore in the warm Gulf Stream.

The first confirmed sighting of a lionfish in the western Atlantic was in 1985 in waters off Palm Beach County in southeastern Florida. Over the next 15 years, the animal was spotted infrequently.

South Florida is one of the world's busiest shipping destinations and marketplaces for the marine ornamental aquarium trade. Brightly colored tropical and subtropical fish are especially prized. Evidence suggests that aquarium hobbyists released individual lionfish into South Florida waters, a hotspot for introductions of marine exotics with 40 species. The lionfish, though, is the only one to have become a major pest.

During the winter of 2000-2001, a well-established lionfish population was discovered at a shipwreck off Beaufort, North Carolina, after their eggs and larvae were carried there by the Gulf Stream.

NOAA scientists began tracking its movements. In less than a decade, lionfish had spread to the Bahamas and the wider Caribbean, Georgia, and South Carolina. In the past few years, lionfish invaded the Florida Keys, the Gulf of Mexico, and the reefs of northwestern South America. Lionfish populations have grown faster and ranged farther than scientists had thought possible.

"No other nonnative marine fish has ever taken off in this way in the western Atlantic and Caribbean," Morris says.

One reason for the lionfish's success is its broad environmental tolerance, with the exception of cold temperature. It thrives from the warm, dark depths of the Gulf Stream off the Carolinas to the sun-lit seagrass beds, coral reefs, and mangroves of the tropics. Waders encounter them in knee-high water and submersibles have documented them nearly a thousand feet below the surface.

A lionfish hunts primarily at dawn or dusk, stalking by camouflage. It drifts along like a clump of seaweed and then hovers motionless, its large pectoral fins arrayed like a cowl, above an unsuspecting animal.

Sometimes the lionfish blows out a jet of water, disorienting its prey, which attempts to flee but instead swims toward the lionfish's waiting mouth. When the lionfish strikes, it swallows prey whole in a single gulp. At other times it herds animals against a reef and suctions them in one by one.

At mid-day, lionfish tend to rest in small groups beneath ledges, in holes or caves, or in reefs. Divers find lionfish swimming upside-down, their white bellies against a ledge roof, bright eyes peering out of the dark.

Many native prey species seem unconcerned when they see a lionfish; they don't swim off. That's because no native predator hunts like it. This naïve fearlessness is often found on isolated islands when a new predator is introduced. On Guam, for instance, a venomous tree snake introduced in the 1950s ravaged bird populations. Native birds had never encountered a predatory snake and had not evolved protective strategies against it.

The lionfish will eat just about any creature worth the effort. Studying stomach contents of lionfish, scientists have found more than 70 species.

Mark Hixon, a marine biologist at Oregon State University, and his team have found that a single lionfish can reduce the number of individual fishes on a small experimental reef by 79% in five weeks. One lionfish consumed 20 small fish in 30 minutes.

It's surprising to find the word "phenomenal" in a peer-reviewed science journal. Yet that's how two scientists describe the rate of expansion of lionfish populations in the western Atlantic and Caribbean. Lionfish have become so abundant that they will almost certainly never be eliminated from these regions, write Mark A. Albins, now a postdoctoral fellow at Auburn University, and Hixon in a 2011 study.

Consider the speed of the lionfish invasion in the Florida Keys.

Lionfish were first reported there in 2009. By the end of 2010, researchers estimated a population of 89,000 individuals. A year later, estimates jumped to 335,000 lionfish. And that's probably a conservative estimate since lionfish often hide in reefs, according to a 2012 study by Benjamin Ruttenberg, a biologist with NOAA Fisheries, and his colleagues.

The vast majority of non-native species don't last long. Against native species, they quickly lose competitions for food—or they become food for predators.

If they do manage to gain a foothold and reproduce, their populations usually remain very small, kept in check by competitors or lack of food.

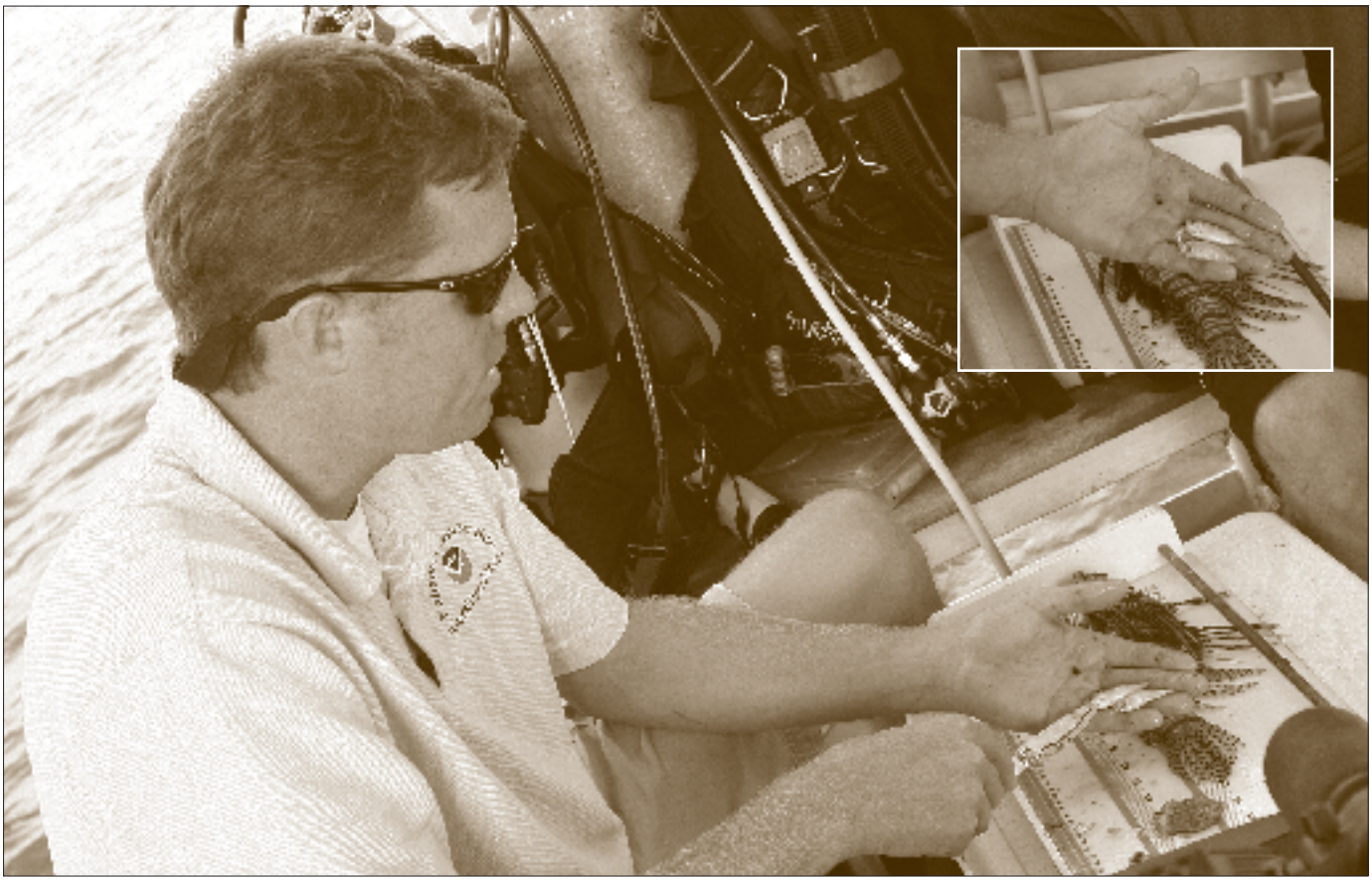
But the non-natives that do become biological invaders can cause vast economic or ecological harm. Invasive species in the United States have devastated agricultural crops, endangered native tree species, and clogged water pipes. Non-native mosquitoes and parasites are dangerous carriers of human diseases such as malaria and yellow fever.

In South Carolina, hydrilla, water hyacinth, *Phragmites australis*, and other invasive plants have damaged aquatic ecosystems but are monitored and controlled with chemicals and other means.

Biological invaders are predators or competitors of half of the species on U.S. threatened or endangered species lists. Damage and control costs for invasive species in the United States are estimated at $137 billion per year, according to a 2005 study by David Pimentel, an ecologist at Cornell University, and his colleagues.

The lionfish is exceptional in the annals of invasive species. It is the only unintentionally introduced marine carnivore to become a destructive invader in the recorded history of the western Atlantic Ocean and Caribbean.

Even so, fishermen, chefs, recreational divers, educators, conservationists, and scientists are finding some success in the Bahamas, Mexico, Cayman Islands, and the Florida Keys



LIONFISH EXPERT. *James A. Morris of the National Oceanic and Atmospheric Administration dissects a red lionfish and finds juvenile vermillion snapper (inset) in its stomach. Lionfish are consuming huge numbers of reef fish in the western Atlantic and Caribbean.*
PHOTOS/NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ACROBATS. *Asian silver carp have invaded the Mississippi River and its tributaries, causing injury to anglers and disrupting river ecosystems.*
PHOTO/T. LAWRENCE/GREAT LAKES FISHERY COMMISSION

in efforts to decrease lionfish densities at local sites.

Their strategy is straightforward—if you can't get rid of an invasive species, harvest a lot of them and eat them. "That's the best long-term strategy for controlling lionfish," says Morris.

Establishing a strong culinary market for lionfish could help manage its population and give native species a better chance to recover. So it's up to the biggest predatory force in the ocean—*Homo sapiens*—to gobble up lionfish and help native groupers and snappers in some locations rebuild their numbers.

Targeting invasive species for food is a growing trend among eco-conscious folks. You've probably heard about locavores—people who eat products of local farms, ranches, and fisheries as often as possible.

Now more and more people are calling themselves "invasivores," a term that James Gorman, a science writer for the *New York Times*, apparently invented in 2010.

Invasivores, for instance, are cooking non-native tiger shrimp (*Penaeus monodon*) caught in the Gulf of Mexico; various species of Asian carp, especially the notorious leaping silver carp (*Hypophthalmichthys molitrix*), caught in the Mississippi River and its tributaries; and the northern snakehead fish (*Channa argus*) in the Potomac River.

A TASTY INVADER

In the shallow, sunlit reefs of the Caribbean, scientists design field experiments, dive often to study lionfish and their predators and prey, and observe interactions among them.

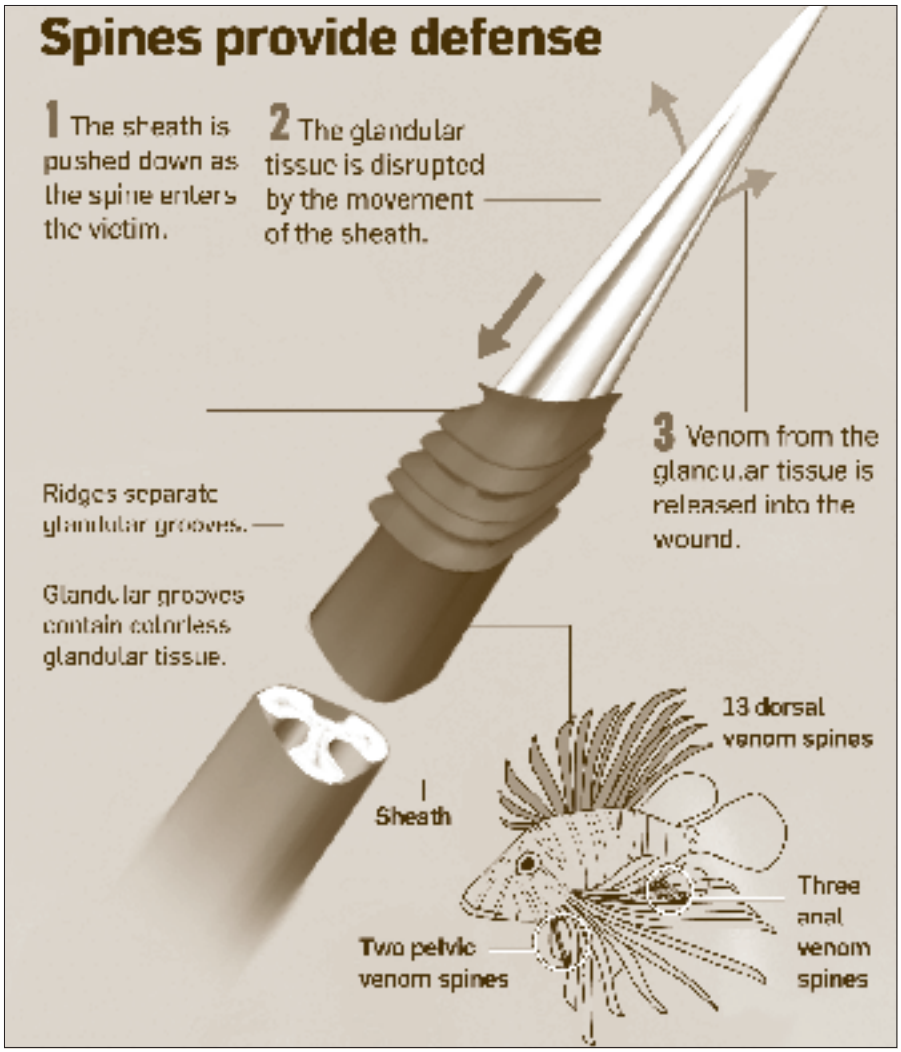
That's far more difficult in the Carolinas, where lionfish live in deeper water offshore. Scuba time, logistics, and financial budgets are limited for fieldwork there, according to Paula Whitfield, a research ecologist at the NOAA lab in Beaufort, North Carolina.

Even so, dive surveys led by Whitfield show that lionfish populations range from 200-to-500 lionfish per 10,000 square meters on hard bottoms in waters off North Carolina. Native snapper-grouper species usually range from 78-to-300 fish for similar-size areas.

Natural variability in fishery populations can be very wide, so it's difficult to measure the invader's impact on fisheries.

"We know a lot of things about the lionfish's life history," says Whitfield. "We know that lionfish are just as abundant as native species here, if not more abundant. They are one of the main fishes that we see in our offshore research, 100-plus feet down. But we don't know, without a shadow of a doubt, the lionfish's impacts on

NON-NATIVE. *Ryan Werner, a charter-boat captain, caught this nearly foot-long Asian tiger shrimp in Little River Inlet in 2011. "It tasted more like a southern [spiny] lobster—firm and kind of stringy—than a local white shrimp," he says.*
PHOTO/RYAN WERNER



The red lionfish's venomous spines can cause swelling, intense pain, and even temporary paralysis.
GRAPHIC/LINDSAY DUBOIS/SOUTH FLORIDA SUN-SENTINEL

snapper-grouper fisheries."

Victor Depuis, co-owner of Lowcountry Scuba on Shem Creek in Mount Pleasant, South Carolina, says that he's seen first-hand evidence that lionfish are taking over snapper-grouper habitat. He leads recreational divers on spearfishing trips to offshore rocks and plateaus.

Ten years ago, groupers, snappers, triggerfish, and black sea bass dominated spearfishing sites, he says. Today, there appears to be a similarly sized biomass, but lionfish far outnumber snapper-grouper species.

On a typical spearfishing site of, say, an acre with four-foot relief at 85-to-130 feet deep about 30 miles offshore, divers in 2013 are likely to see 200 lionfish, Depuis says.

Four divers can spear 120-to-150 on the first dive of the day. (No bag limit exists on lionfish.) On a similar site a decade ago there would have been only three or four lionfish in total, he says, and the rest would be snapper-grouper species.

If divers don't kill all of the lionfish at a site and return a week later, they will probably find dozens of lionfish there again. "It'll look like you haven't touched it," Depuis says.

Guiding up to 60 dive excursions a year, he's turned lionfish overabundance into a business opportunity. He purchases harvests from his diving customers at $5 apiece. Because he has a commercial distribution license, he can sell lionfish at $10 apiece directly to restaurants or to a wholesaler.

Harvesters and cooks should take care when handling lionfish. Its venomous spines give a nasty sting. A single prick can cause swelling and intense pain. In a small number of cases it has caused temporary paralysis.

The lionfish's quills, though, are easy to cut away if you use appropriate gloves and other precautions. A lionfish filet, which is free of venom, is similar in yield to that of a grouper or snapper of the same size. A bigger lionfish can be fileted, but smaller ones are often fried whole.

Ounce-for-ounce, lionfish is expensive, though popular with customers, according to Drew Hedlund, executive chef at Fleet Landing restaurant on Charleston Harbor.

He acquires lionfish from a seafood packer who buys them from commercial fishing boats at the Murrells Inlet docks. The largest and most consistent volume of lionfish in South Carolina is landed as bycatch in the snapper-grouper fishery.

"Some days three lionfish will roll in the backdoor, and another day 50 will come in."

His customers seem intrigued by the lionfish story. "We explain that

Handle with Care

Watch out for lionfish's venomous dorsal, pelvic, and anal spines. Unless a person is allergic to the venom, lionfish (*P. volitans*) stings are not fatal. Stings, though, can be very painful, cause numbness, swelling, and even temporary paralysis.

The National Oceanic and Atmospheric Administration (NOAA) recommends treating a lionfish puncture wound by immersing the wound area in hot (not scalding) water for 30-to-90 minutes and to seek medical attention as soon as possible. The Poison Help Hotline, (800) 222-1222, is available 24-hours a day, every day.

TRENDSETTER. *Brian Barber, sous chef at Fleet Landing, a waterfront restaurant in Charleston, prepares a South Carolina-caught lionfish for a lunchtime crowd. Lionfish has become an increasingly popular delicacy, he says.*
PHOTO/GRACE BEAHM

we're trying to get lionfish off the reefs," says Hedlund. "Lionfish are eating young snapper and grouper, and they don't belong here. So we're combatting them."

His "eat lionfish to save snappers and groupers" story allows Fleet Landing to stand out as an innovator in Charleston's intensely competitive culinary marketplace.

THE SUPER INVADER

Reproduce early and often and then disperse offspring far and wide—that's how some non-natives become biological invaders. At one year of age, lionfish are sexually mature, spawning several times a month and in every season.

The great majority of fish species fertilize eggs externally. That is, the female fish expels eggs into the water column, and the male expels sperm toward the eggs to fertilize them.

Lionfish spawn externally as well, but with a crucial difference. During each spawning event, the female lionfish releases two gelatinous, mucous sacs, each holding thousands of eggs. The protective sac, which looks like a comb jelly, is hollow. The male fertilizes the eggs through an opening in the casing, allowing sperm to find eggs more easily instead of searching for them in a water column subject to shifting currents.

When the casing dissolves and lionfish larvae emerge, ocean currents disperse them for 20-to-40 days until they are juveniles. Ocean currents have carried lionfish larvae from the Bahamas to New England, though the young don't survive the winter there.

An adult lionfish lives as long as 15 years, continuously reproducing. In its lifetime, a female lionfish will release two million eggs each year. Its long life span, frequent and productive spawning, and capacity to disperse larvae great distances have allowed the lionfish to spread with incredible speed.

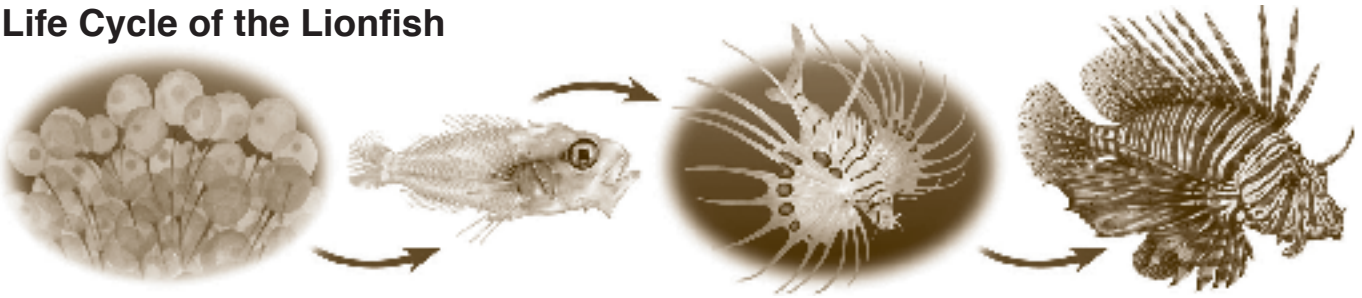
By contrast, many native reef fish are late bloomers or require special conditions in which to spawn.

For example, Nassau grouper (*Epinephelus striatus*) was once a heavily overfished species in the western Atlantic and Caribbean. It spawns only in December and January, always in the light of the full moon, and always in the same locations. When huge numbers of Nassau grouper would gather under a brilliant night sky, they were easy targets for fishing operations.

Because too many spawning adults were harvested year after year, the fishery collapsed. Nassau grouper is now considered a "species of concern," in the U.S. South Atlantic, meaning that it's in critically low numbers,

FLAVORFUL. *Diners say they enjoy lionfish's firm, creamy filets.*
PHOTO/GRACE BEAHM

Life Cycle of the Lionfish



Eggs, 15,000–30,000 per spawning event

Every 1–2 weeks the female releases two mucous-encapsulated egg masses that are fertilized by the male.

Larval stage, 20–40 days less than 2 cm (0.8 in.)

Approximately 36 hours later, the eggs hatch into larvae, which are dispersed by ocean currents.

Juvenile, up to 10 mos. 2–10 cm (0.8–4 in.)

Juveniles spend most of their time in one small area before expanding their range.

Reproductive adult, 1 yr. greater than 10 cm (4 in.)

Although lionfish in their native range can live to 15 years, little is known about the lifespans of Atlantic invaders.

GRAPHIC/DAWN WITHERINGTON/LOXAHATCHEE RIVER DISTRICT

though not considered threatened or endangered. But Nassau grouper is listed as threatened by the International Union of the Conservation of Nature, a global environmental group, and it is also a protected species in the state of Florida.

Since the early 1990s, the South Atlantic Fishery Management Council (SAFMC) has been trying to restore populations of overharvested reef fisheries such as red snapper, Warsaw grouper, misty grouper, Nassau grouper, and others.

The council has instituted trip limits, species limits, size limits, gear regulations, seasonal closures, total-allowable-catch limits, a commercial limited-entry program for some species, and quotas. The council also designed new marine-protected areas in the region from the Carolinas to eastern Florida.

The reauthorization of the Magnuson-Stevens Act in 2007 required NOAA and regional fishery councils to work further together on annual catch limits for every federally managed fish species, which now number more than 500.

Over the past two years, the SAFMC has developed some of the toughest regulations in its history, closing shallow-water grouper fisheries during the first four months of each year and instituting severe limits for numerous species.

There are 73 species in this region's reef-fish populations: snappers and groupers, of course, but also porgies, triggerfish, jacks, tilefishes, grunts, spadefishes, wrasses, and sea basses.

Roger Pugliese, a biologist with SAFMC, says that commercial and recreational fishermen can "take as many lionfish as they want" with spears and nets, although fish traps, which inadvertently catch snapper-grouper species, are off-limits.

The council monitors lionfish populations in part through a federally funded but state-managed Marine Resources Monitoring, Assessment, and Prediction (MARMAP) program.

Joseph Ballenger, MARMAP coordinator at the S.C. Department of Natural Resources, and his colleagues spend 50-to-70 days a year from April to October at sea, deploying fish traps outfitted with deep-water cameras to sea bottoms some 30-to-70 miles offshore.

Scientists had once hoped that lionfish populations could be controlled in part by a profitable commercial fishery using baited traps.

But that optimism is fading, says Ballenger.

Although attracted by bait, many lionfish will swim "like little hovercrafts" above the traps, refusing to enter, says Dawn Glasgow, a Ph.D. candidate in integrative biology at the University of South Carolina, who collaborates with Ballenger. Over three years, 2010-to-2012, baited traps have caught a total of just three lionfish off South Carolina.

The majority of the lionfish population off the Carolinas appears to be living below 150 feet where temperatures are more stable, but that's also the depth boundary for safe diving.

Localized spearfishing in marine-protected areas and other sites can greatly reduce lionfish numbers there, says Pugliese, but deep-water population reservoirs can allow lionfish to reproduce and re-invade.

Lionfish don't venture into South Carolina's state waters, which extend to three miles off the coast. Some snapper-grouper species, however, do spend some of their life history in state-managed estuaries.

"Lionfish is not a state waters' issue, and I hope it stays that way," says Mel Bell, director of the Office of Fisheries Management at the South Carolina Department of Natural Resources (SCDNR). "Our state waters are a little too cool for them. But we do have a stake in fisheries in federal waters, especially recreational snapper-grouper, so we would like for those lionfish to be gone."

At maturity, snappers and groupers are top reef predators, competing with lionfish for food and shelter. The reef food chain is complex, but bigger carnivorous fish, of course, tend to eat

NEAR RECORD. *This lionfish, caught in South Carolina waters, measured 17 inches. The world record is 18.5 inches.*
PHOTO/GRACE BEAHM

smaller ones.

In lab experiments, though, some adult snapper-grouper species would rather go hungry than attack lionfish and risk tangling with its venomous spines.

Nassau grouper, moreover, could be losing habitat to the fiercely territorial lionfish. In an Oregon State University study, Nassau grouper would swim away from shelter if lionfish were present.

"The lionfish seems to have a lot of confidence in its venom," says Christie Wilcox, a science blogger and Ph.D. candidate studying fish genetics at the University of Hawaii. "When confronted with a threat, it doesn't swim away but instead turns and faces it head on, nose down, bringing its venomous dorsal spines forward, sort of like a bull pointing its horns as if to say, 'Go ahead, I dare you.' "

What keeps lionfish in control in their native range? About 15 lionfish species inhabit the Indo-Pacific. As a result, prey species encounter them more often and learn to avoid them. By contrast, only two lionfish species—the red lionfish and a far smaller number of a sister invasive lionfish species (*P. miles*) —inhabit the western Atlantic and Caribbean. Perhaps that's why New World prey won't swim away when they see lionfish, offering this invader many easy pickings.

WHAT INSTIGATED THE INVASION?

Hundreds of non-native species—most of them tiny worms or crustaceans—found in U.S. coastal waters haven't caused any evident harm or concern and perhaps never will. Yet other species suddenly grow out of control and become pests.

David Knott, a Charleston-based consulting biologist for natural-resource agencies, has documented more than 60 non-native invertebrate species in South Carolina freshwater and saltwater ecosystems.

"Knowing which species are likely to become invasive is very difficult," says Knott. "Different risk analyses have been done. But we don't really study the potential local impacts of a non-native species until it has already become invasive."

Decades of research show that a significant "disturbance"—a dramatic change such as overfishing, climate change, or pollution—can offer some non-native species chances to flourish and become pests.

The more disturbed an ecosystem becomes, the greater the likelihood that a non-native species can enter a vacated ecological niche and take it over, scientists say.

Some snapper-grouper species in the U.S. southeastern Atlantic were severely overfished, a major disturbance that, among other pressures, could have allowed the lionfish to thrive.

"There was certainly more opportunity for niche availability and niche takeover" because of overfishing, says James A. Morris of NOAA in Beaufort, North Carolina.

An important question now is the degree to which the lionfish invasion could affect the future of snapper-grouper fisheries. The invasion might prevent some fishes from regaining their niches.

"Can you rebuild stocks to the same size that you could before the lionfish takeover?" asks Morris. "That's a 20-to-30 year question. If stock-rebuilding plans are unsuccessful, will it be because lionfish have inhibited their recovery?"

WHAT TO DO

Wind-swept Carteret County, North Carolina, is a maritime wonderland bounded by bays, coastal rivers, creeks, inlets, and the sea. In June 2013, it was home to the "If You Can't Beat 'Em, Eat 'Em" Spearfishing Tournament, a 10-day derby in which divers competed for prizes while chefs prepared the invaders for feasts.

Lionfish derbies have become popular social events across the Caribbean and South Florida, helping to raise awareness of the invasion and its consequences. But this was the first one in North Carolina.

"Many sport fishermen don't even realize that the lionfish are out there," says Debby Boyce, manager of Discovery Diving in Beaufort, North Carolina, who helped organize the event. "If you don't dive, you probably won't see them. But they're everywhere."

FACT FINDER. *Stephanie Green, a marine ecologist and postdoctoral fellow at Oregon State University, collects data on lionfish during the REEF Lionfish Derby at Green Turtle Cay, Bahamas, in 2013.*
PHOTO/REEF ENVIRONMENTAL EDUCATION FOUNDATION

Steve Broadhurst, a dive safety officer with the North Carolina Aquarium in Pine Knolls, says that lionfish are found there in depths of 100-to-150 feet and about 30 miles offshore.

"In the water they are quick and agile," Broadhurst says. "But they often do a hiding-in-plain-sight thing. They go to the bottom where they are easy to spear. They must depend on their protective coloring or their venom because they don't swim away after being speared once and wriggling off the spear. They stay on the bottom to be speared again—and again and again. It's like picking up trash in the park."

Researchers are gathering data from lionfish derbies from North Carolina to the Caribbean.

"We're interested in understanding the relative abundance of lionfish, and we can measure that in part by lionfish hunting efforts," says Whitfield of the NOAA lab in Beaufort, North Carolina. "We can quantify the efforts the divers have to undergo getting the lionfish. We can get a lot of biological information from the lionfish specimens and divers. We can learn how long the divers are staying under water and what sort of information they are collecting. We can also dissect the fish and analyze stomach contents, so we can understand what lionfish are eating."

Sea Grant-funded researchers in the U.S. Southeast and the Caribbean are studying lionfish-removal techniques at various sites, hoping to learn which of three common techniques—short-term derbies, trapping, and continuous harvesting—is the most effective under various conditions.

How do lionfish populations respond to intensive, local fishing efforts that use different harvesting techniques? How quickly do lionfish repopulate an area after being removed? Do native fish recolonize areas once lionfish are removed? How many targeted efforts would be needed each year to keep invaders under control?

"We might find that there are regional differences and that what works in, say, Puerto Rico reefs to control lionfish might only be applicable there," says Maia Patterson McGuire, a Florida Sea Grant extension agent specializing in invasive species. "These research projects are not designed to come up with the ultimate answer for the entire Atlantic. But if we start seeing some consistency among findings in different locations, we might be able to make some broadly applicable management recommendations."

All this begs the question of what to do with the removed lionfish. If the answer is to eat them, then who will do the eating? Is there a culinary

HARVEST WITH CARE. *Gregg Waugh, a fishery biologist and president of SafeSpear LLC, markets specialized safety items, including puncture-resistant gloves, for lionfish harvesters.*
PHOTO/GRACE BEAHM

market large enough to knock back lionfish populations?

Harvesters must take more than one-quarter of the mature lionfish population each month on any particular site—a reef, shipwreck, or marine protected area—just to keep it from growing out of control, studies show.

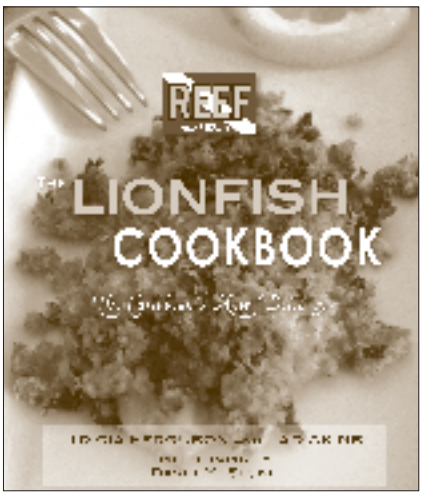
Yet the culinary market for lionfish in the Carolinas is very small, although diners say they like it once they taste it, comparing it favorably to triggerfish and black sea bass.

"Lionfish will be a boutique item" for restaurants, says Gregg Waugh, a fishery biologist and president of SafeSpear LLC, which markets safe-harvest items for lionfish—specialized spears, puncture- and water-resistant bags, puncture-resistant gloves, and spine clippers—to be used by fishermen, researchers, fishery managers, and non-governmental organizations.

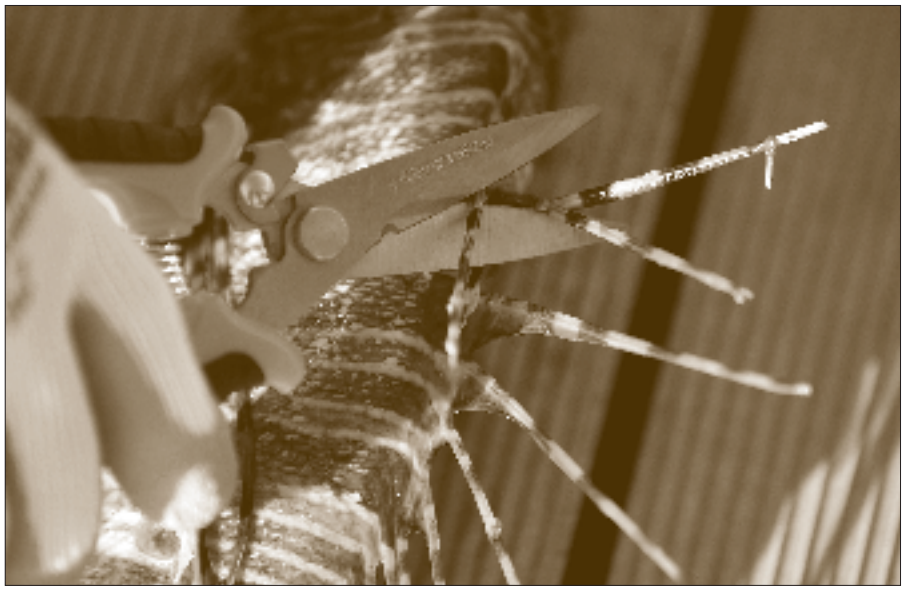
"That you can eat it whole adds to the appeal of lionfish," says Waugh. "People go ga-ga when they see it whole. We also want to get the commercial guys to target lionfish. And once we turn more recreational people onto it, they'll eat it too."

Today, a small number of seafood chefs tout triggerfish, which harvesters used to throw back as "trash fish."

"It took 10-to-15 years to get triggerfish accepted," says Debby Boyce of Discovery Diving. "Lionfish could be the new triggerfish."



A lionfish cookbook is available for purchase at www.reef.org/catalog
IMAGE/REEF ENVIRONMENTAL EDUCATION FOUNDATION



SAFETY FIRST. ***A lionfish's venomous spines are easy to cut away, but always take suitable precautions when harvesting and cleaning them.***
PHOTO/GRACE BEAHM

The nonprofit Reef Environmental Education Foundation (REEF) has published a lionfish cookbook in an effort to show fishermen and chefs how to clean and prepare the region's new tasty delicacy.

In Florida, officials are so eager to get rid of lionfish that they have dropped recreational harvesting rules. In 2013 the Florida Fish and Wildlife Conservation Commission suspended license requirements for recreational fishermen targeting lionfish if they used certain equipment, including a pole spear, a Hawaiian Sling, a handheld net, or any spearing device that is specifically designed and marketed exclusively for lionfish.

Even so, expect this hardy, aggressive, competitive, and exceptionally propagative species to continue expanding its population and territory.

"The lionfish," says Whitfield of NOAA, "is the perfect little survivalist. It has become part of the Atlantic community. The question is, will it just be a part of the community or take over the community? If people have anything to say about it, it won't take over. With fishing, and with perhaps other strategies, we can keep its populations lower."

Potential impacts by the Indo-Pacific red lionfish, *Pterois volitans*, and far smaller numbers of a sister species, *P. miles*, in U.S. South Atlantic waters include:

- reduction of forage-fish biomass;
- increase in algal growth due to herbivore removal;
- competition with native reef fish;
- cascading trophic impacts on economically important species under federal management;
- competition with native species could hamper stock rebuilding efforts for the 73 snapper-grouper species;
- impacts on commercial and recreational fisheries, the aquarium trade, and coastal tourism industry; and
- increase in frequency of venom stings to recreational swimmers, fishermen, and divers.

Source: South Atlantic Fishery Management Council

Concerns over potential illegal lionfish sales

Lionfish (*P. volitans*) caught in the waters of the Carolinas, Georgia, and eastern Florida is safe to eat if properly prepared. But Steve Otwell, seafood specialist with Florida Sea Grant, is worried that someday illegal trading in lionfish could bring potentially unsafe lionfish to the region.

Now to be clear—Otwell is not worried about lionfish venom harming consumers. Properly prepared lionfish harvested from Florida to North Carolina is safe to eat.

But U.S. consumers someday could be exposed to ciguatera toxin in lionfish harvested from certain regions in the Caribbean and sold illegally in the United States.

Ciguatera is a foodborne illness caused by eating certain reef fish whose flesh is contaminated with toxin produced by algae most commonly found in certain tropical and subtropical waters in the Caribbean.

Some reef-fish species, including snappers and groupers and lionfish, have been known to carry ciguatera toxin. Odorless, tasteless, and very heat-resistant, this toxin is not neutralized by conventional cooking. Ciguatera toxin can cause particular gastrointestinal and neurological symptoms that in some cases have been reported to last for weeks to months.

There are no known cases of ciguatera poisoning from consuming snapper-grouper species in South Carolina, Georgia, or eastern Florida. Ciguatera toxin in these waters is very rare.

But rapidly expanding recreational catches of lionfish in the Caribbean might help stimulate illegal distribution channels into U.S. seafood markets. Unscrupulous activities could involve selling of recreational catches or misidentification for the original source or area of harvest.

Commercial fishermen and managers in the Caribbean generally know the locations of ciguatera toxin in the region and avoid those areas.

More and more recreational fishermen, however, are harvesting growing volumes of lionfish, and they could be tempted to make illegal gains through a black market.

Restaurants and other seafood outlets are required to purchase fish only from licensed vendors and distributors. But there has always been a "back door" illegal market in fish that's very difficult to enforce.

"All of a sudden, everybody's trying to catch lionfish," says Otwell, "and you could have roadside vendors selling them." The South Carolina Department of Natural Resources (SCDNR) tracks landings of marine fish caught in South Carolina for commercial purposes in the state.

"If the system works correctly, and people abide by existing laws, all lionfish that are landed for commercial purpose in South Carolina would be tracked by our office," says Mel Hall, director of SCDNR Office of Fisheries Management. "There have been 'back door' approaches to getting all sorts of fish to restaurants, but under current law these are illegal, and if uncovered can be dealt with."

It's possible that some lionfish could be sent north from the Caribbean as part of an illegal market that does not provide crucial information about where the fish comes from.

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NEWS & NOTES

Growing higher-value oysters in Carolina waters

South Carolina's oysters are rich in flavor, tasting of the sea, and many are harvested from the wild in clusters and served up at oyster roasts.

But new opportunities could be expanded for farm-raised single oysters in the premium half-shell market. Farming oysters using off-bottom methods—growing them in mesh containers raised off the seabed—can produce larger numbers of the high-value "single" oyster sought by local chefs.

South Carolina growers could grow a nicely shaped, consistent product with off-bottom methods, which would allow them to break into more lucrative niche markets, says Julie Davis, living marine resources specialist with the S.C. Sea Grant Extension Program.

"Oysters are widespread and abundant over the South Carolina coast," Davis says. "But as far as optimal sites for growing premium oysters using off-bottom methods, we're at the beginning. This could be an entrepreneurial opportunity for people living on the coast, including those already involved in the shellfish industry."

South Carolina has many naturally rich, healthy habitats for oysters. Oyster farmers acquire a permit to use some bottom areas and harvest oysters from the seabed, primarily as clusters. Later, oyster farmers spread shell in those areas, ensuring that the next generations of bivalves will have a hard surface upon which to grow.

Other areas are permitted especially for mariculture, which employs various techniques to cultivate seafood products in saltwater. Off-bottom oyster farming is mariculture and typically uses single-set oysters produced in a hatchery as seed.

Hatchery-raised seed helps give the oyster a beautiful shape at the beginning. The oyster will maintain that shape, including the coveted deep cup, until harvest, as long as its growing conditions are not too crowded.

Oyster seeds to be grown on optimum sites for high-end markets.
PHOTO/JULIE DAVIS/S.C. SEA GRANT EXTENSION PROGRAM

High-end restaurants serving oysters raw on the half-shell are looking for consistent supplies of nicely shaped oysters.

"People eat with their eyes," says Davis. "If you're paying a premium for an oyster in a restaurant, you're interested in food presentation and the dining experience. You're looking for pretty oysters."

The abundance of oyster spat in South Carolina's coastal waters results in oyster clusters and few naturally occurring single oysters. Oyster larvae, barnacles, and algae attach to older shells on existing reefs creating the clusters of oysters that we enjoy. But that also causes crowding on the reef, which creates long, skinny oysters.

For individual oysters to achieve a more desirable shape (wider shell, deeper cup), they require space. So researchers and oyster farmers have devised various methods to allow them to do just that.

For example, oyster farmers in some regions of the country raise oyster seed in cages that are periodically raised out of the water to air dry. Large seed can withstand the air-drying by clamping shut. But when younger, newly settled fouling animals such as barnacles are deprived of water, those animals die.

"They might be out of the water for 18-to-20 hours," says Davis. "This reduces fouling on the cage and on the oysters. Reduced fouling gives the seed more space to grow when the cage is dropped into the water again." Preventing growth of other animals on the oysters is key to growing a nicely shaped oyster and keeping labor costs low.

Today, oyster farmers in many regions around the world are using various off-bottom methods to reduce fouling and grow steady supplies of premium oysters for the lucrative high-end restaurant market.

"We need to find the most suitable methods and locations to grow South Carolina oysters for the half-shell market," says Davis. "There are many different types of gear available, so we don't need to reinvent the wheel. Let's test the gear that others have used successfully."

Oyster farmers need detailed information about new oyster-farming methods before investing in expensive seed and gear. So Davis and her colleagues aim to identify optimal sites to grow out oyster seed along the South Carolina coast. Then they will install off-bottom technologies with oyster

NEWS & NOTES

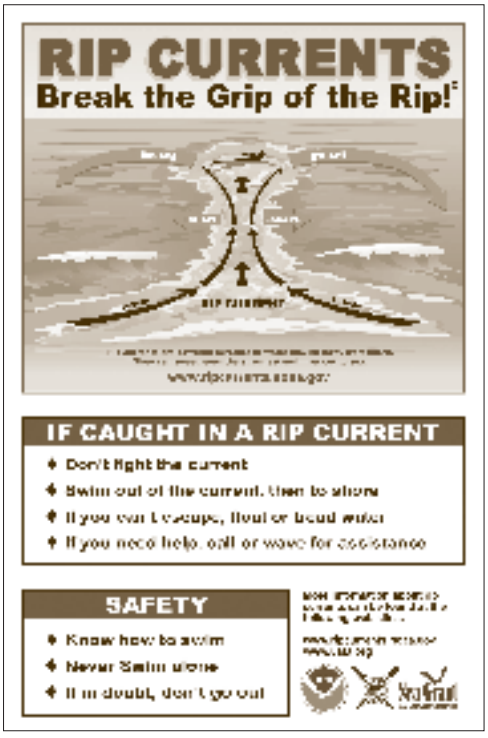
seed of various ages to study their survival and growth rate. This will help determine future costs of production for oyster farmers.

For more information about this or other fisheries- and aquaculture-related projects, contact Julie Davis at (843) 255-6060 ext. 112 or julie.davis@scseagrant.org.

State park enhances rip-current awareness

Rip currents remain a threat for beachgoers at the South Carolina coast, but now Hunting Island State Park is taking steps to enhance safety for their guests.

Michael Slattery, the S.C. Sea Grant Consortium's coastal processes extension specialist based at Coastal Carolina University, has developed rip-current educational materials, including a public talk for park guests and community members, and a follow-up training session for ranger staff.



In his public talk, Slattery explained to beachgoers how to recognize and avoid rip currents.

"I tell beachgoers to look for features that can generate rip currents," says Slattery. "For instance, any structures that are perpendicular to the coast (groins, jetties, and piers) frequently have rip currents form right alongside them. Also, a sandbar running parallel to the coast might not be solid. It might have channels that cut through the bar. At low points in the bar, rip currents are common. If you can avoid these physical structures, you can avoid most rip currents."

Slattery recommends using polarized sunglasses to increase your chances of seeing both the sandbar and any channels through the bar that may have a strong rip current.

In his training sessions at Hunting Island State Park, Slattery described how rangers could educate the public about rip currents and what their role should be in case of a rip-current emergency. The S.C. Sea Grant Consortium has provided rip-current signage for each of Hunting Island's beach access locations and many other locations along the South Carolina coast.

Slattery will continue offering public seminars at Hunting Island State Park in 2014. He will also offer further training to rangers so they can provide public educational talks on a more regular basis.

For more information about rip currents or these educational opportunities, contact Michael Slattery at (843) 349-4155 or mslattery@coastal.edu.

S.C. Environmental Awareness Award call for nominations

The S.C. Environmental Awareness Award committee is seeking nominations for the 2013 award. The deadline for nominations is January 31, 2014.

The S.C. General Assembly established the award, now in its 21st year, during the 1992 legislative session to recognize outstanding contributions made toward the protection, conservation, and improvement of South Carolina's natural resources.

Each year the public is invited to submit nominations that are then reviewed by an award committee, which considers excellence in innovation, leadership, and accomplishments that influence positive changes. Members of the award committee include representatives of the S.C. Sea Grant Consortium, S.C. Department of Natural Resources, S.C. Department of Health and Environmental Control, and the S.C. Forestry Commission.

More information, including guidelines, criteria, past recipients, and a nomination form, is available at www.dnr.sc.gov/news/scenvironawareaward.html.

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EBBS & FLOWS

American Meteorological Association 94th Annual Meeting

Atlanta, Georgia
February 2-6, 2014

This year's theme is "Extreme Weather—Climate and the Built Environment: New Perspectives Opportunities, and Tools." The meeting will bring together an interdisciplinary group of scholars, technologists, communicators, educators, and stakeholders. Extreme weather and climate events represent an intersection that combines scientific inquiry, technological advances, societal implications, and public awareness. For more information, visit annual.ametsoc.org/2014.

Social Coast Forum 2014

Charleston, South Carolina
February 18-20, 2014

The NOAA Coastal Services Center is hosting the second biennial Social Coast Forum to see and share how social-science tools and methods are being used to address the nation's coastal issues.

Participants will discuss the use of social-science tools, data, and methods to address topics such as climate change, land-use planning, ecosystem services, and human uses of the oceans.

Visit www.csc.noaa.gov/socialcoastforum for more information.

2014 Ocean Sciences Meeting

Honolulu, Hawaii
February 23-28, 2014

The 2014 Ocean Sciences Meeting is an important venue for scientific exchange across marine-science disciplines. Increasing evidence of multiple human impacts on the oceans makes this is a critical time for the largest international assembly of ocean scientists, engineers, students, educators, policy makers, and other stakeholders to gather and share their results on research, application of research, and education. For more information, visit www.sgmeet.com/osm2014.

Subscriptions are free upon request by contacting: Annette.Dunmeyer@scseagrant.org

ATTENTION SCHOOL TEACHERS! The S.C. Sea Grant Consortium has designed supplemental classroom resources for this and past issues of *Coastal Heritage* magazine. *Coastal Heritage Curriculum Connection*, written for K-12 educators and their students, is aligned with the South Carolina state standards for the appropriate grade levels. Includes standards-based inquiry questions to lead students through explorations of the topic discussed. *Curriculum Connection* is available online at www.scseagrant.org/education.